ESC-TR-95-019

PATENTS & LICENSES

Through 1994

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

This report is based on studies performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology. The work was sponsored by the Department of the Air Force under Contract F19628-95-C-0002.

FOR THE COMMANDER

Gary Tutungian
Administrative Contracting Officer
Contracted Support Management

PATENTS & LICENSES

Through 1994

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

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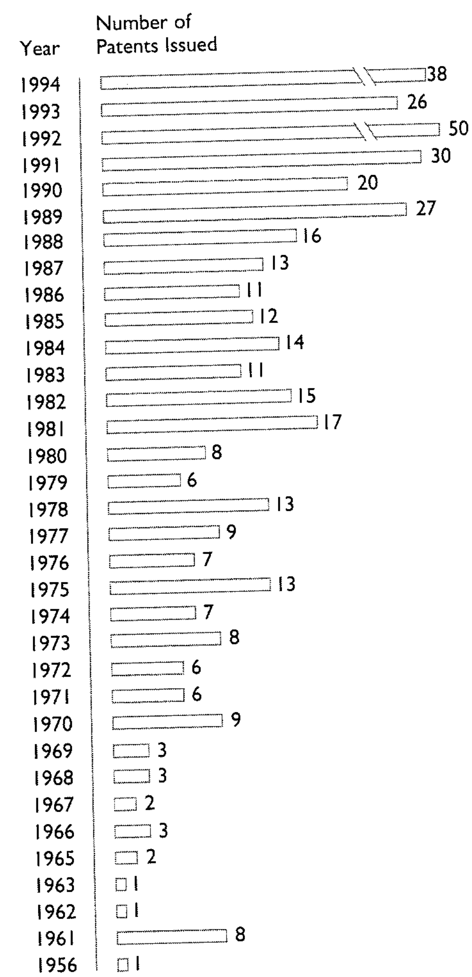
EXECUTIVE SUMMARY

The rapidly changing and growing world of information and new technologies has made patents an increasingly valuable resource to industry and, as such, has significantly advanced the nation's preeminence as a global leader. Of the 5 million patents issued by the Patent and Trademark Office in U.S. history, 1 million were issued in only 14 years, from 1976 to 1991.[1]

MIT Lincoln Laboratory
Patents 1956–1994 (By Calendar Year)



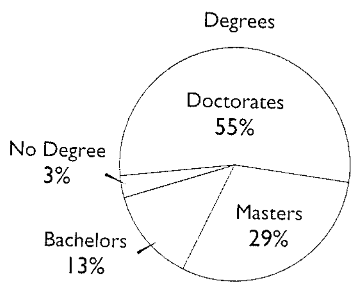
Over the years, Lincoln Laboratory's pioneers in research and development have helped carve out new industrial markets in American business. Their efforts not only advanced exploratory research among their colleagues but also paved the way for implementation of new technologies that are now standard nationwide. The philosophy of the Laboratory, which encourages creativity and the development of new ideas, has produced 416 patents, 276 of which are licensed. Many of these inventions have been licensed and protected worldwide.

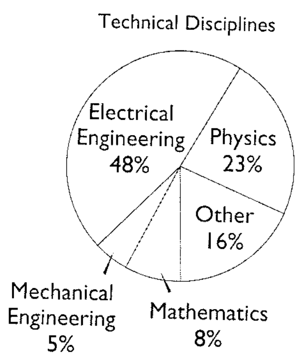
Lincoln Laboratory's professional staff exemplifies the creativity, imagination, and innovation that has made the Laboratory so successful. Eighty-four percent of the professional staff hold advanced degrees, sixty-nine percent of which are in electrical engineering and physics disciplines, with others in diversified scientific fields and subject areas.

As early as 1956, one of the Laboratory's eminent scientists, **Professor Jay W. Forrester**, was issued a patent for his invention, the Magnetic Core Memory Device. This concept increased both the speed and reliability of computer memory systems at a time when "computer" was far from being a household word. Since that early initiative, the Laboratory has carried its research mission into fields ranging from material and devices to radar and optical systems, thereby broadening its national technical leadership. From 1968 to 1980, **Professor Henry I. Smith** pioneered the development of techniques at

1. "Patents: A Valuable Resource in the Information Age," Connie Wu and Ellen Calhoun, *Special Libraries Association*, Winter 1992.

MIT Lincoln Laboratory
Staff Composition
as of 1994





Lincoln Laboratory for fabricating submicrometer and nanometer structures. As current Director of the NanoStructures Laboratory at MIT, Professor Smith, along with his coworkers, is responsible for a number of innovations in submicrometer structures technology and applications, including x-ray lithography, for which he has been granted numerous patents. **Dr. John C.C. Fan**, Chairman and Chief Executive Officer of Kopin Corporation, which he founded in 1984, has been awarded patents for his concepts of Silicon-on-Insulator and Thin-Film Liftoff. For his work in Solid State, **Dr. Aram Mooradian** has been granted several United States and foreign patents based on his invention, the Solid State Microlaser, an optically pumped microlaser that can be mass-produced at low cost using semiconductor processing and packaging technology. Dr. Mooradian is Vice Chairman, Executive Vice President, and Chief Technical Officer of Micracor, a company he co-founded in 1989.

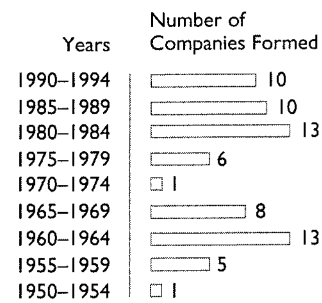
Today, Lincoln Laboratory researchers continue in the enterprising spirit of their predecessors. They are making enormous contributions that directly affect significant areas: microelectronics, the environment, cancer therapy, digital video transmissions, electronics, and optics. **Dr. Christine A. Wang, Mr. James W. Caunt,** and **Professor Robert A. Brown** combined their talents to design, build, and test a new reactor that produces the most precisely controlled and uniform semiconductor films reported to date. **Dr. Bernard B. Kosicki** has invented a method to treat the back surface of a back-illuminated charge-coupled device to stabilize the surface and improve the light collection efficiency. **Drs. Bernadette Johnson** and **John J. Zayhowski** are developing a low-cost sensor that has environmental applications in diverse areas such as soil and groundwater, landfills, and smokestacks. **Dr. Alan J. Fenn's** invention, the Adaptive Nulling Hyperthermia Array, holds promise to improve cancer therapy techniques on humans. **Dr. Alice M. Chiang,** whose work in developing the Matrix-Matrix Product Processor bestowed Lincoln Laboratory with the 1986 DARPA/STO Outstanding Technical Breakthrough Award, has been granted patents for her Video-Bandwidth Compression concept.

Dr. Carl O. Bozler has invented the Cleavage of Lateral Epitaxial Film for Transfer manufacturing process where a high-quality single-crystal film of a semiconductor can be peeled from the substrate on which it was grown and transferred to almost any other substrate. This invention can be applied to the manufacture of solar cells, light-emitting diodes, and active matrix liquid crystal display flat panel displays. Finally, **Mr. Eric A. Swanson's** invention, Optical Coherence Tomography, has ophthalmic applications that will provide an important new diagnostic capability for retinal diseases such as glaucoma and macular degeneration.

In addition to patent enterprises, Lincoln Laboratory research has produced an impressive number of spin-off companies throughout the country. Sixty-seven businesses have been spawned from Laboratory research, employing more than 136,000 people and generating more than $16 billion in sales annually.[2] Moreover, Laboratory researchers have authored over 60 books, and each year they produce more than 500 journal articles, technical presentations at national and international conferences, and technical reports on a variety of topics in many fields.[3] In 1988, the *Lincoln Laboratory Journal* was launched. This publication is distributed to almost 6,000 persons, agencies, institutions, and companies nationwide.

Responding to both professional challenges and public need, the Laboratory has grown into a multifaceted center of research and development. In this vanguard spirit, and determined in its commitment to excellence in the development of state-of-the-art technologies, Lincoln Laboratory continues to be the nation's launching pad from which today's research becomes tomorrow's reality.

Spin-Off Companies
By Five-Year Increments



Total Number of Companies Formed: 67

2. *Spin-Off Companies from MIT Lincoln Laboratory,* Lexington, Mass.: MIT Lincoln Laboratory (May 1995).

3. *Unclassified Publications of Lincoln Laboratory,* Lexington, Mass.: MIT Lincoln Laboratory (annual).

PATENT PROCESS

LINCOLN LABORATORY OVERVIEW

Since its establishment in 1951, MIT Lincoln Laboratory has actively pursued its mission to "carry out a program of research and development pertinent to national defense with particular emphasis on advanced electronics." Toward this end, the Laboratory promotes scientific and technological research providing the best solutions to address the needs of the nation. By patenting and licensing inventions, technology originally developed to meet the specific needs of the Department of Defense and other government agencies can be applied to solve problems in the civilian sector; this substantially benefits the nation's economy.

MIT TECHNOLOGY LICENSING OFFICE

The MIT Technology Licensing Office works with industry, venture capital sources, and entrepreneurs to find the best way to commercialize the new technologies developed at MIT and Lincoln Laboratory. Historically, the Massachusetts Institute of Technology's approach has been to patent inventions. This past decade, however, the Institute brought a greater emphasis to licensing. The success of this change is impressive with over 100 patents issued last year alone; 56% of these patents were licensed or optioned at the time of issue (MIT and Lincoln Laboratory combined). A branch office opened at Lincoln Laboratory several years ago, which was a direct outcome of this success.

SELECTED PROFILES IN CREATIVITY

Professor
Jay W. Forrester

Received a B.S. in Electrical Engineering from the University of Nebraska and an S.M. in Electrical Engineering from the Massachusetts Institute of Technology. In 1956, he joined the MIT faculty as Professor at its Sloan School of Management. He is now Germeshausen Professor Emeritus and Senior Lecturer at the Sloan School.

Multicoordinate Digital Information Storage (Magnetic Core Memory) Device

The Magnetic Core Memory Device, patented in 1956, consists of a plane array of small doughnut-shaped ferrite cores; four wires threaded through each core carry current pulses that were used to sense the information stored in the memory and to write in new information. This concept increased both the speed and reliability of computer memory systems. For over two decades, random-access, coincident-current magnetic storage was the standard memory device for high-speed digital computers. Jay Forrester holds the basic patent for this invention.

For over two decades, random-access, coincident-current magnetic storage was the standard memory device for high-speed digital computers.

United States patent 2,736,880 has been granted for this invention.

Solid State Microlaser

Microchip lasers are small, robust, compact, high-performance diode-pumped solid state lasers that can be manufactured in large volume at low cost and can perform with capabilities far beyond those of diode lasers. A relatively low-cost diode laser is used as an excitation source to pump a solid state laser "chip" made from Nd:YAG of less than 1 mm^3 in size to convert the poor spatial mode output of the diode laser to a spectrally pure, low-noise beam. These output beam characteristics exceed those of typical diode lasers and open up numerous commercial applications not possible before. Semiconductor device fabrication and packaging techniques are used to mass produce these devices.

These output beam characteristics exceed those of typical diode lasers and open up numerous commercial applications not possible before.

The microchip laser concept was developed by Aram Mooradian at MIT Lincoln Laboratory. The patents and technology have been exclusively licensed from MIT by Micracor for commercial development. Commercial low-noise microchip lasers are being produced by Micracor for cable TV applications with output power levels of more than 100 mW cw at a wavelength of 1300 nm. These high-power, low-noise systems will provide performance beyond the present low-power DFB diode lasers for fiber-optical, high-channel-capacity cable TV. In addition, these devices are used in analog fiber link applications for remote operation of antenna systems. Tuning capability for such devices exceeds 50 GHz, which allows application to frequency-division-multiplexed communications as well as microwave radar systems. These microchip lasers have also been operated in the *Q*-switched mode with record short pulses of 200 picoseconds. These short-pulse, high-peak-power devices will find unique uses in medical, materials processing, and defense applications.

Several United States and foreign patents have been granted based on this invention.

Dr. Aram Mooradian

Received a B.S. in Physics from the Worcester Polytechnic Institute and a Ph.D., also in Physics, from Purdue University. He is Vice Chairman, Executive Vice President, and Chief Technical Officer of Micracor, a company he cofounded in 1989.

Dr. Bernard B. Kosicki

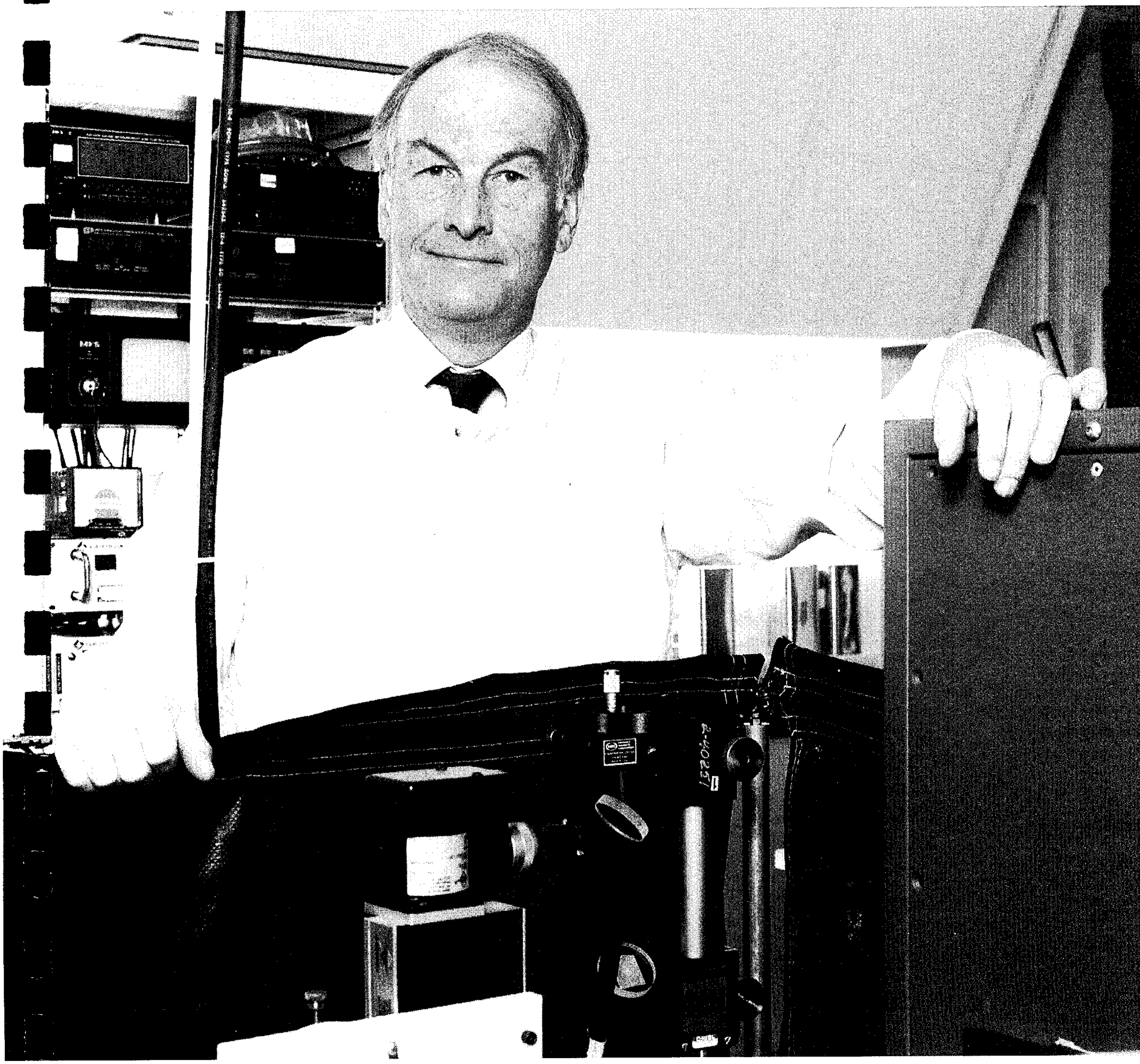
Received a B.A. in Physics with distinction from Wesleyan University in 1961. He obtained an M.A. (1962) and Ph.D. (1967) degrees from Harvard, both in Solid State Physics. Dr. Kosicki was a Member of Technical Staff at Bell Telephone Laboratories at Murray Hill for six years, where he conducted research on growth, structure, and dielectric and electroluminescent properties of various thin film materials and structures. He subsequently became involved in CCD and process technology shortly after these devices were invented. For the next ten years, Dr. Kosicki served in managerial positions at Sperry Research Center, General Instruments Microelectronics, and Fairchild Semiconductor, involved first in MNOS device development and pilot production, then in process and product engineering for microprocessor production, and finally in advanced silicon technology development.

Barrier Layer Device Processing

This patent disclosed a way to treat the back surface of a back-illuminated CCD to stabilize the surface and to improve the light collection efficiency. When the device is constructed, the thick wafer is first glued face down to a substrate with epoxy, then thinned to the desired thickness. The substrate gives it rigidity and mechanical strength after it is thinned. Subsequently, the back surface must be treated in a way to improve its stability and light collection efficiency. Many previous researchers had used methods that were unstable in time and required complex ways of treating the surface temporarily with chemicals or charging it with light. Bernard Kosicki, along with colleagues, applied the laser doping process previously developed at Lincoln for this purpose. In contrast to some of the previous work cited above, it was compatible with maintaining the temperature of the thin-device-epoxy-substrate sandwich below the temperature that the epoxy could withstand while making the back surface treatment permanent.

This patent disclosed a way to treat the back surface of a back-illuminated CCD to stabilize the surface and to improve the light collection efficiency.

United States patent 5,198,881 has been granted for this invention.



Professor
Henry I. Smith

Received a B.S. in Physics from Holy Cross. He has an M.S. and Ph.D. in Physics from Boston College. He pioneered the development of techniques for fabricating submicrometer and nanometer structures. From 1977 to 1980, he was an Adjunct Professor at MIT, where he established and directed the Submicron Structures Laboratory. In December 1980, Henry Smith was appointed a Professor of Electrical Engineering at MIT, where he now devotes full time to research and teaching. In January 1990, he was named to the Joseph F. and Nancy P. Keithley Chair in Electrical Engineering. He is currently Director of the NanoStructures Laboratory at MIT.

Comformable Photomask Lithography

In recent years, Henry Smith's research has emphasized submicron structures, nanofabrication, methods for preparing Semiconductor-on-Insulator films, electronic devices, quantum effects in sub-100-nm structures, and optoelectronic device fabrication.

Research has emphasized submicron structures, nanofabrication, methods for preparing Semiconductors-on-Insulator films, . . .

He and his coworkers are responsible for a number of innovations in submicrometer-structures technology and applications, including comformable photomask lithography, x-ray lithography, spatial-phase-locked electron-beam lithography, interferometric alignment, graphoepitaxy, surface-energy-driven grain growth, achromatic holographic lithography, sub-100-nm Si MOSFETs, and a variety of quantum-effect structures such as lateral-surface-superlattices and planar-resonant-tunneling field-effect transistors in GaAs/AlGaAs.

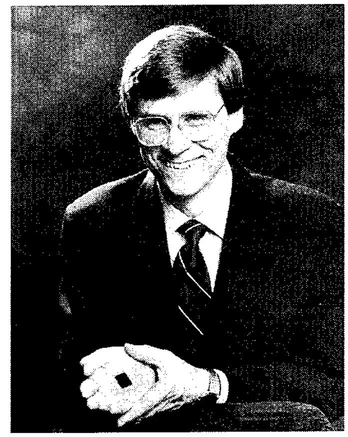
Numerous United States patents have been granted for his work in x-ray lithography.

The CLEFT Process: Method of Producing Sheets of Crystalline Material

The Cleavage of Lateral Epitaxial Film for Transfer (CLEFT) process provides a manufacturing technique where a high-quality single-crystal film of a semiconductor, such as gallium arsenide or silicon, can be peeled from the substrate on which it was grown and transferred to almost any other substrate. This is a potentially low-cost method for providing single crystal films since the original single crystal substrate, which is costly, can be reused for the preparation of additional films. At MIT Lincoln Laboratory, a high-efficiency gallium arsenide solar cell was made on a CLEFT film and then transferred to a thin glass substrate, which resulted in a device measured to have record power-to-weight ratio, a highly desirable quality for use in space. The patents for the CLEFT process have been licensed to Kopin Corporation for application to the manufacture of solar cells, light-emitting diodes, and active matrix liquid crystal display flat panel displays.

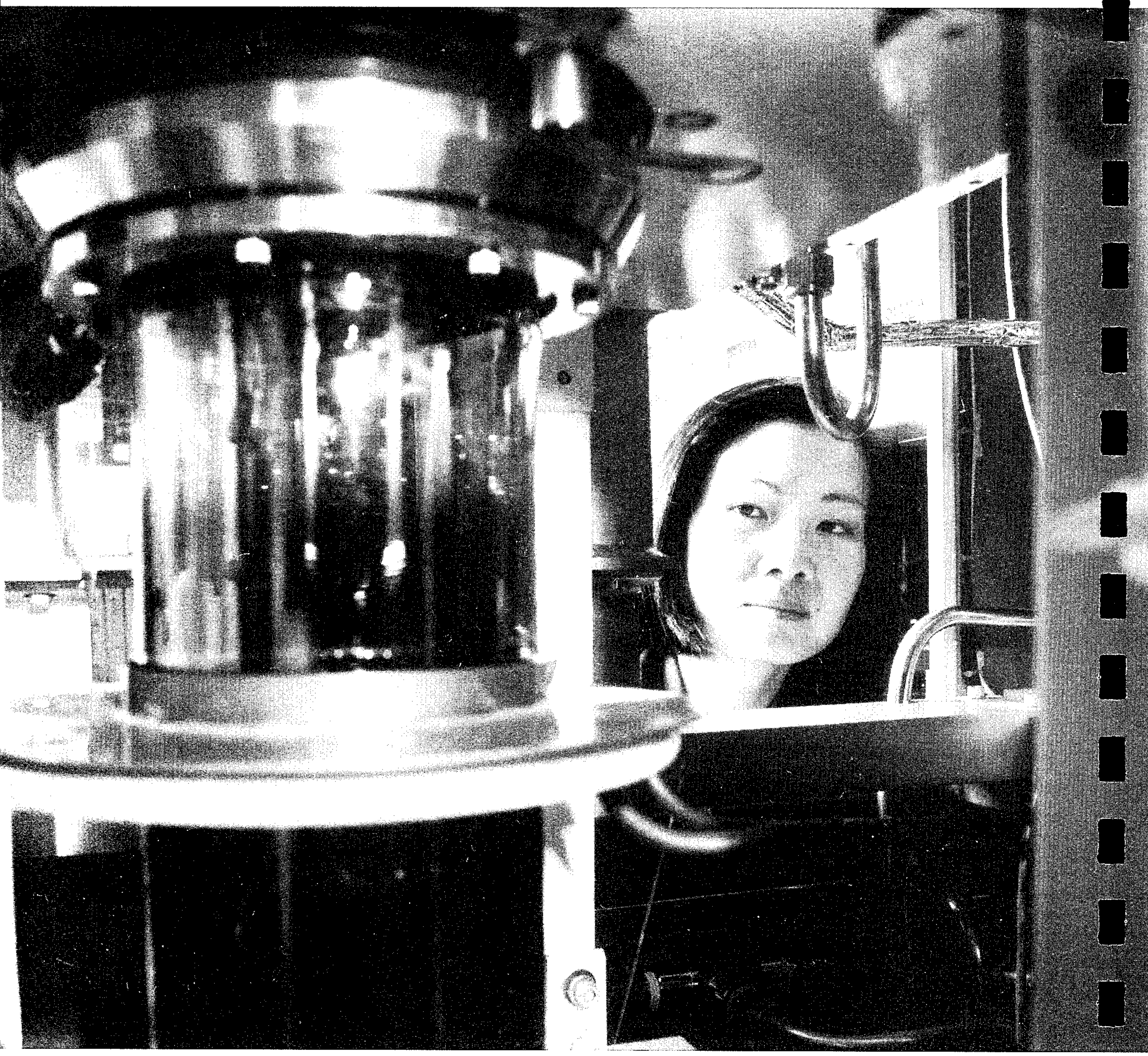
This is a potentially low-cost method for providing single crystal films since the original single crystal substrate, which is costly, can be reused for the preparation of additional films.

United States patents 4,727,047; 4,816,420; and 4,837,182 have been granted for this invention.



Dr. Carl O. Bozler

Received a B.S., an M.S., and a Ph.D. in Electrical Engineering from The Ohio State University, Columbus.



Vapor Phase Reactor for Making Multilayer Structures

A new reactor for producing semiconductor epitaxial layers such as GaAs, AlGaAs, and InGaAs has been designed, built, and tested. Results show that the reactor produces the most precisely controlled and uniform semiconductor films reported to date. Recognizing that the specific dynamics of the gas in the reactor have a profound influence on film quality, the researchers used a light-scattering technique to visualize the gas flow in the reactor. A numerical model of reactor fluid flow and heat and mass transfer was developed to simulate epitaxial growth and to establish critical parameters for fabricating uniform layers with abrupt compositional changes.

Results show that the reactor produces the most precisely controlled and uniform semiconductor films reported to date.

The reactor, which permits the highly reproducible production of these epilayers, will increase yields and reduce production costs. The uniformity is especially critical for diode-pumped solid state lasers used in military applications, micro- and macromachining, and medical applications, as well as for coherent diode laser arrays used in space communications, optical recording, and optical computing. In addition, reduced maintenance and simplicity of design are attractive for commercialization.

United States patent 4,997,677 has been issued for this invention, which is licensed by Bellcore and Spire Corporation and commercially developed by Spire with the support of the U.S. Air Force.

Dr. Christine A. Wang

Received an S.B. in Materials Science and Engineering, an S.M. in Metallurgy, and a Ph.D. in Electronic Materials, all from the Massachusetts Institute of Technology.

Mr. James W. Caunt

Received an Associate's Degree in Mechanical Engineering from the Wentworth Institute of Technology, a B.S. in Industrial Technology from Northeastern University, and an M.B.A. from Babson College.

Professor Robert A. Brown

Received an S.B. and an M.S. from the University of Texas at Austin and a Ph.D. from the University of Minnesota. He is currently the Warren K. Lewis Professor and Head of the Department of Chemical Engineering at the Massachusetts Institute of Technology.

Mr. Eric A. Swanson

Received a B.S. degree in Electrical Engineering from the University of Massachusetts, Amherst, in 1982 and an S.M. degree in Electrical Engineering from the Massachusetts Institute of Technology in 1984. His Master's thesis work was done at MIT Lincoln Laboratory on optical spatial tracking.

Professor James G. Fujimoto

Received the following degrees from MIT: an S.B., an S.M., and a Ph.D. in Electrical Engineering.

Dr. David Huang

Received the following degrees from MIT: an S.B. and an S.M. in Electrical Engineering and a Ph.D. in Medical Engineering and Medical Physics. He has an M.D. from Harvard Medical School.

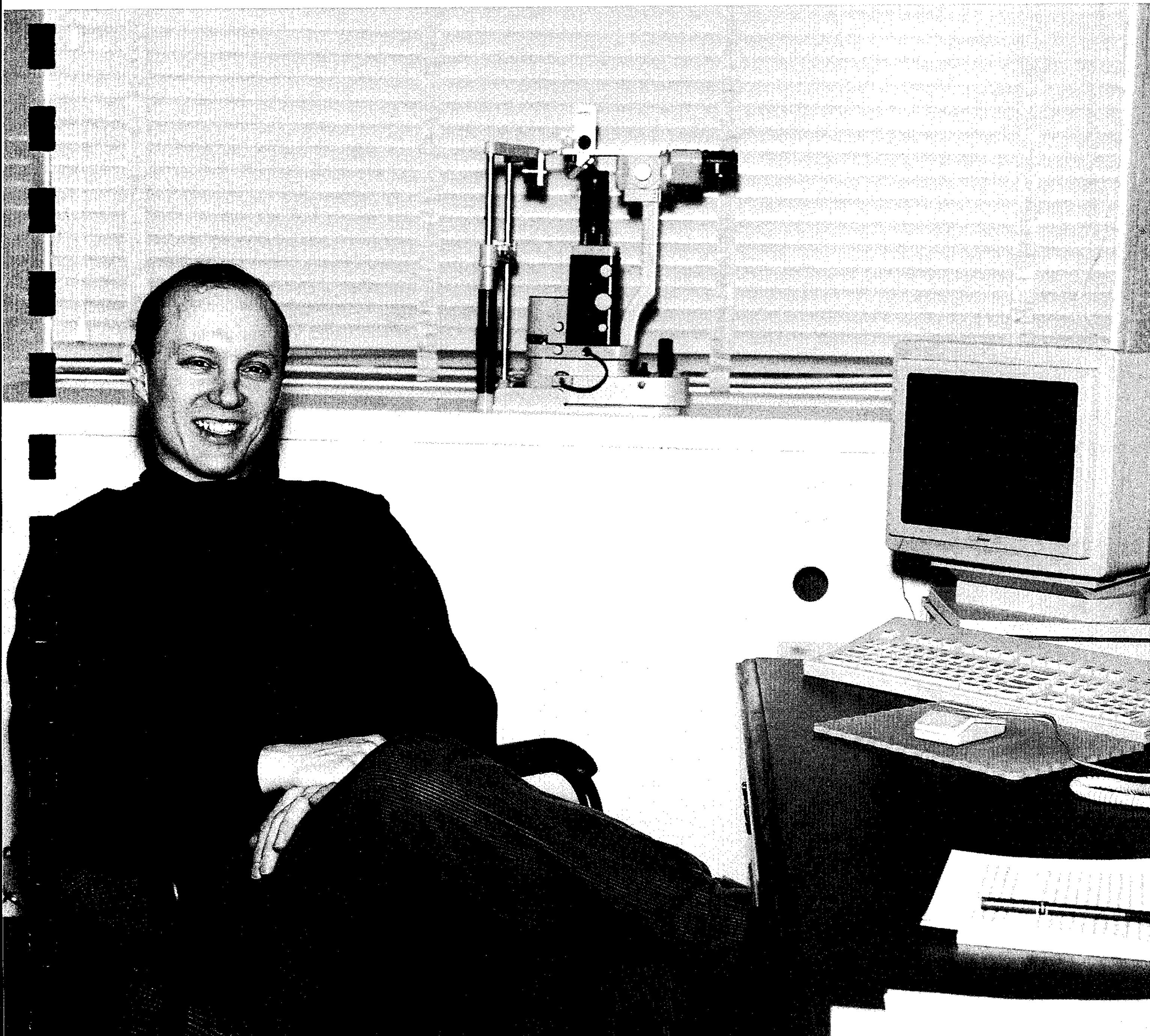
Optical Coherence Tomography

Optical coherence tomography (OCT) is a new technique for noncontact cross-sectional imaging based on optical coherence domain reflectometry (OCDR). OCDR uses a broad bandwidth light source, such as an LED, coupled to a Michelson interferometer. One arm of the interferometer leads to a reference mirror, the other to the sample of interest. Only when the reference and sample arm lengths are matched to within the source coherence length is optical interference detected. By scanning, the reference mirror reflectivity profiles of the sample are obtained. Slewing the reference mirror at a constant velocity allows for heterodyne detection at the Doppler frequency shift, thereby achieving high-resolution (~10 μm) and high-sensitivity (~100 dB) longitudinal ranging measurements. OCT, an extension of OCDR, combines multiple longitudinal scans to form gray scales or false color cross-sectional images.

It allows for high-resolution imaging in biological tissue, particularly in ophthalmic applications where the OCT device may provide an important new diagnostic capability for a variety of retinal diseases such as glaucoma and macular degeneration.

Eric Swanson, along with James G. Fujimoto, Associate Professor in Electrical Engineering and Computer Science at MIT in Cambridge, and former MIT student David Huang developed this technology that has a wide range of applications, including measuring optical components and biological tissues. It allows for high-resolution imaging in biological tissue, particularly in ophthalmic applications where the OCT device may provide an important new diagnostic capability for a variety of retinal diseases such as glaucoma and macular degeneration.

United States patent 5,321,501 has been granted for this invention.



Dr. John C. C. Fan

Received a B.S. in Electrical Engineering from the University of California, Berkeley, and an M.S. and a Ph.D. in Applied Physics from Harvard University. He is the Chairman and Chief Executive Officer of Kopin Corporation in Taunton, Massachusetts.

High-Resolution Solid-State Imaging Devices Using Silicon-on-Insulator and Thin-Film Liftoff

Working with colleagues, John Fan has been granted many patents for the concepts of Silicon-on-Insulator and Thin-Film Liftoff. The combination of these technologies provides the foundation for high-resolution active-matrix liquid-crystal displays (AMLCDs) that operate at video speeds.

The approach is ideal for integrated displays providing fast, full-color, high-resolution images for multimedia applications.

These imaging devices represent a major advance in the performance and manufacture of AMLCDs. The approach is ideal for integrated displays providing fast, full-color, high-resolution images for multimedia applications. Some of the applications range from portable presentation systems, to head-mounted displays for entertainment and industrial applications, to large screen monitors and televisions, including high-definition televisions.

Many United States patents (such as 4,371,421; 4,670,088; 4,727,047; and 5,273,616) have been granted and licensed by MIT.

Video-Bandwidth Compression

The emerging use of digital video transmission techniques minimizes channel noise and interference, which secures a robust transmission but increases the transmission bandwidth. The bandwidth of the future high-definition television (HDTV) is at least a few hundred megahertz. It would be much more efficient, and in some cases necessary, to develop a compact, low-power coder to encode a video signal at the transmitter end to reduce the channel transmission bit-rate requirement and a similar decoder to decode the information at the receiver end while maintaining a high picture quality.

As a reult of these inventions, a low-power multimedia terminal or a low-cost HDTV receiver based on charge-domain signal processing chips could be produced in the near future.

For video compression applications, redundancy within a single frame can be reduced by an interframe, transform-domain coding technique. Recently, transform image coding based on the Discrete Cosine Transform (DCT) algorithm has been proven to be a near optimum method for good-quality, low-data-rate image transmission. Currently, interframe predictive coding has been widely used to remove redundancy between frames. For these applications, two charge-domain components have been invented: one is a two-dimensional (2D DCT), the other is a full search motion detection and estimation chip with a subpixel search resolution. Both chips can be used either in a video transmitter or receiver. As a result of these inventions, a low-power multimedia terminal or a low-cost HDTV receiver based on charge-domain signal processing chips could be produced in the near future.

United States patents 5,030,953 and 5,126,962 have been granted for this concept.

Dr. Alice M. Chiang

Received a B.S. in Physics from the National Taiwan University and a Ph.D. in Physics from Virginia Polytechnic Institute and State University, Blacksburg. From 1973 to 1976, Dr. Chiang was employed at Honeywell Radiation Center, where she worked on mercury cadmium telluride (HgCdTe) and gallium phosphide photoconductive (PC) and photovoltaic (PV) detectors, solar cells, and pyroelectric detector arrays. Dr. Chiang's focus of research at Lincoln Laboratory has been on silicon charge-coupled devices for high-speed analog signal processing. Lincoln Laboratory was the recipient of the 1986 DARPA/STO Outstanding Technical Breakthrough Award for Dr. Chiang's achievement in developing the matrix-matrix product processor. She is a member of Sigma Pi Sigma and Phi Kappa Phi honor societies.

Fiber-Optic Sensor for Remote Spectroscopy of Soil, Water, and Air Contaminants

Currently, two types of fiber-optic chemical sensors exist: one in which a chemically sensitive analyte or reagent is located at the tip of a fiber, and one in which the fiber serves as a light guide for laser radiation. In the first type, an analyte must be found for every chemical under investigation, and the sensors are often not reusable. In the second type, laser sources are restricted to the visible to near-infrared for long fiber lengths because ultraviolet (UV) radiation does not propagate well in fibers. Unfortunately, UV radiation can often provide the highest sensitivity measurements because of the (typically) strong absorption features and increased scattering cross sections compared to longer wavelengths.

This sensor will be simple, low-cost, and suitable in hostile environments.

Bernadette Johnson and John J. Zayhowski are developing a UV sensor consisting of a near-infrared diode pump that is coupled, via optical fiber, to a self-*Q*-switched frequency-tripled or -quadrupled solid-state laser. By locating the pump radiation and lasing materials at opposite ends of the fiber, they can take advantage of the high transmissivity of optical fiber for near-infrared radiation and produce UV radiation only at the location where the measurement is made, which can be hundreds of meters or even kilometers from the primary laser source. This sensor would use miniature lasers, developed at MIT Lincoln Laboratory, whose output would be pulsed, with pulse widths less than 1 nanosecond, to permit fluorescence lifetime measurements. Emitted or scattered radiation would be either collected by a second fiber and returned to a spectrometer for analysis or detected in situ by photodetectors colocated at the sensor head.

A sensor that permits in situ spectroscopy has application in areas as diverse as soil and groundwater monitoring of hydrocarbons, landfill monitoring of methane, and smokestack monitoring of polycyclic aromatic compounds. This sensor will be simple, low-cost, and suitable in hostile environments.

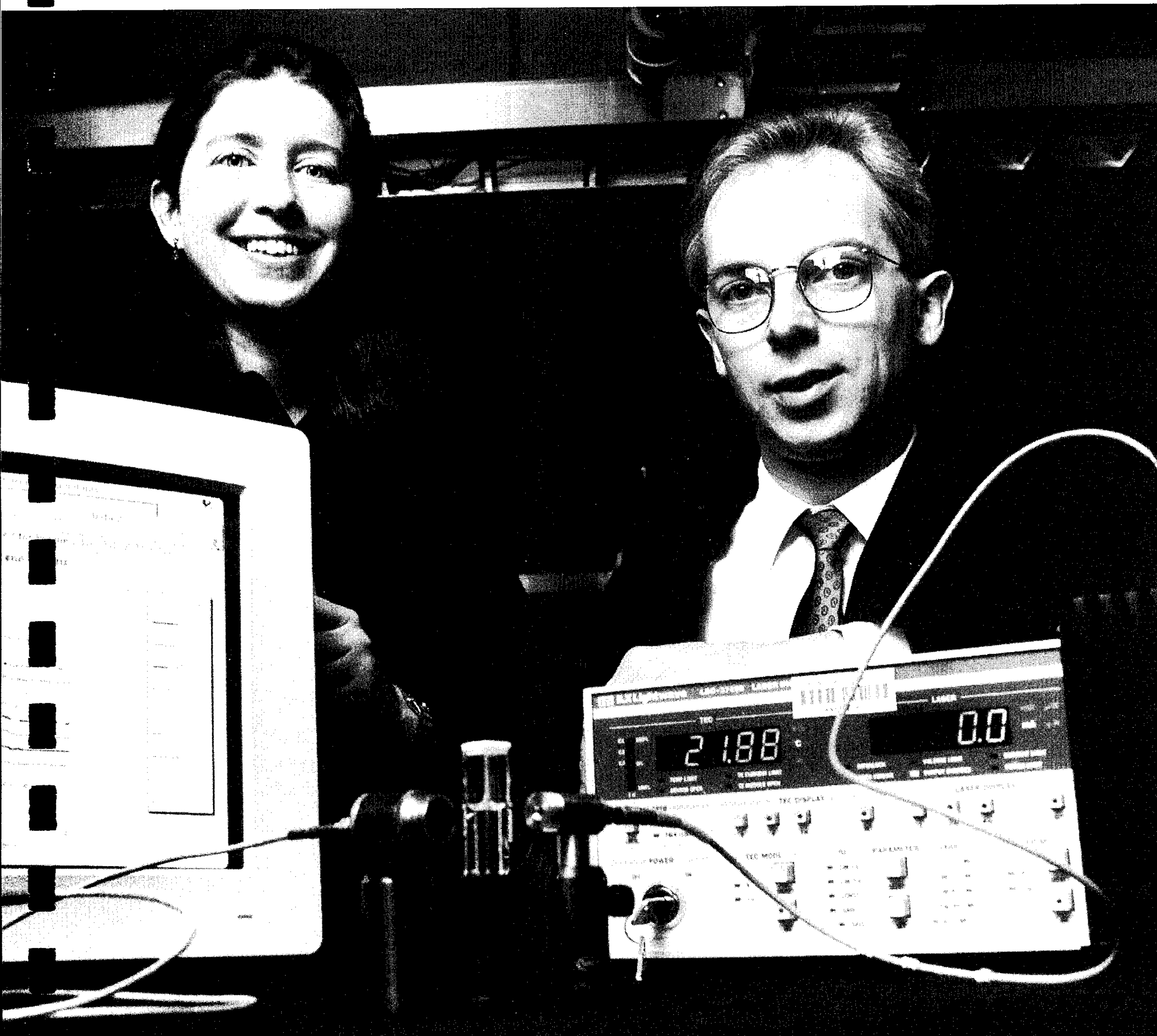
A patent for this invention is pending.

Dr. Bernadette Johnson

Received a B.S. degree in Physics from Dickinson College and the University of Heidelberg in Germany, an M.S. degree in Condensed Matter Theory from Georgetown University, and a Ph.D. in Plasma Physics from Dartmouth College. Before joining Lincoln Laboratory, Dr. Johnson worked for Applied Science Technology and the Argonne National Laboratories.

Dr. John J. Zayhowski

Received the following degrees from MIT: a joint S.M./S.B. in Electrical Engineering and Computer Science and a Ph.D. in Electrical Engineering. Before joining Lincoln Laboratory, he worked at the Texas Instruments Central Research Laboratory. Dr. Zayhowski is a Hertz Fellow and a member of Tau Beta Pi, Eta Kappa Nu, Signa Xi, and the Optical Society of America.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Adaptive Nulling Hyperthermia Array

Modern cancer treatment centers use tissue-heating "hyperthermia" to shrink cancerous tumors in the human body. However, the current clinical use of hyperthermia is hampered by the limited ability of existing equipment to selectively heat tumors. In this invention, adaptive nulling and/or focusing with auxiliary feedback field probes controls a high-power phased array hyperthermia system to reduce or enhance the field intensity at selected positions in and around the target body while maintaining a desired focus at a cancerous tumor. In so doing, "hot spots" in healthy tissue can be avoided or reduced while enhancing heating of a tumor during radio frequency (RF), microwave, or ultrasound hyperthermia treatment.

If the adaptive phased array hyperthermia technique can be used clinically on humans, an improved cancer therapy could be achieved.

To date, preclinical testing of the adaptive phased array hyperthermia system at three medical centers has shown promising results.

If the adaptive phased array hyperthermia technique can be used clinically on humans, an improved cancer therapy could be achieved.

United States patent 5,251,645 has been granted for this invention.

Dr. Alan J. Fenn

Received a B.S. degree from the University of Illinois at Chicago and M.S. and Ph.D. degrees from Ohio State University, all in Electrical Engineering. Before coming to Lincoln Laboratory, Dr. Fenn worked for Martin Marietta Aerospace Corporation in Denver, Colorado. He has served as an associate editor in the area of adaptive arrays for the *IEEE Transactions on Antennas and Propagation*. He is a member of the American Society for Therapeutic Radiology and Oncology.

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